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DISCOVERY

Solar refrigeration: a viable alternative for rural health centre

Ebunilo POB[1✉], **Kwasi-Effah CC**[2]

[1]Department of Mechanical Engineering, University of Benin, P.M.B 1154, Benin City, Nigeria, E-mail: ebunilo17@yahoo.co.uk
[2]Department of Mechanical Engineering, University of Benin, P.M.B 1154, Benin City, Nigeria, E-mail: collinshicent@yahoo.com

✉**Corresponding Author:**
Email: ebunilo17@yahoo.co.uk

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General Note
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ABSTRACT
Most rural areas lack access to essential medicines/vaccines due to the unreliable power supply in Nigeria. Rural health centres will be critical in achieving lasting health improvements if an economic and sustainable power supply is maintained. In this paper, a solar powered health centre having an average energy consumption of 3517.5Watt-Hour was conceptualized and analysed. The analysis has shown that a solar powered health centre is 7% economical than fossil fuel (petrol) powered health centre in first year and will exponentially increase in coming years. Also, by comparing with PHCN (Power Holding Company of Nigeria), the breakeven point was found to be 2.5 yrs. The design analysis has shown that the solar powered health center is a stand-alone energy system and is economically viable. The solar energy resource is renewable, have zero or low GWP (global warming potential) and zero ODP (ozone depletion potential), it is environmentally friendly, noiseless and stress free during operation.

Key words: Solar energy, Refrigeration, Health Centre, Cost, Economic, Renewable

1. INTRODUCTION

In Nigeria, majority of our people live in rural areas where they have very limited or sometimes no access to modern health care services. Very few qualified medical practitioners will readily accept to work in the rural areas for obvious reasons like lack of electricity supply and basic medical infrastructures (Oluyombo, 2005). While acknowledging the MDGs (Millennium Development Goals) as a worthy step in the right direction to create a road map towards improving the state of health in our rural community, the committee on Nigerian Millennium Development Goal 2011 reported that more than 1million children still die annually before the age of 5 years, many of which are from preventable diseases (www.nigeria.unfpa.org). This is due to the fact that most rural areas in the country lack access to essential medicines/ vaccines.

The relationship between health and energy is compelling. A reliable energy strategy for rural areas will be critical in achieving lasting health improvements. For instance, Immunization programs depend upon reliable refrigeration to preserve vaccines to prevent or eradicate dangerous diseases including Polio, Diphtheria, Tetanus, Pertussis, Tuberculosis Measles, Yellow Fever, and Hepatitus. These vaccines can be stored for up to one month and require a stable temperature between 0°C (32°F) and 8°C (46°F). Once the vaccines have been exposed to temperatures outside this range, potency is forever lost (Antonio, 1998). Hence, it is important that, rural health clinic must be able to freeze ice packets to carry the vaccines in coolers to surrounding sites served by the health clinic.

Fossil fuels can power motor generators for electrical service in rural health centre, but these generators are often nonfunctional, always expensive, emit green house gases and usually reserved for emergencies when available. However, renewable energy from the sun is an abundant and ubiquitous resource which has zero or low GWP (Global Warming Potential) and ODP (Ozone Depletion Potential), and is thus more environmentally friendly (http://solarpowerengineering.com). Although capable of providing plentiful and reliable electricity, these resources are largely untapped. Hence, this paper is aimed at utilizing solar energy, a cost effective alternative which is highly reliable for powering rural health center appliances and compression refrigeration.

2. MATERIALS AND METHODS

2.1. Component quantity and capacity

Having conducted a survey in some rural health clinics in the country, the major appliances found and energy consumed by each appliance are shown in Table 1. From Table 1, the total average energy consumed per day is 3517.5WH. Hence, we need to find the size of each component needed to power the system.

2.2. Solar panel Sizing

Table 1

Energy consumed by appliances

Medical Appliances	Power (Watts)	On-Time (Hr/Day)	Average Time(Hr/Day)	Average Energy Consumed/Day (Watt-Hr)
Vaccine Refrigerator/ Freezer	60	6.0 - 12.0	9	540
Energy Bulb (5)	75	6.0 - 12.0	9	675
Microscope	10	1	1	10
Centrifugal Nebulizer	150	0.3 - 2.0	1.15	172.5
Vaporizer	40	1 - 4.0	2.5	100
TV	130	1.0 - 6.0	3.5	455
Stereo	10	1.0 - 12.0	6.5	65
Electric Sterilizer	1200	0.5 - 2.0	1.25	1500
Total	**1675**			**3517.5**

Since the average daily insolation period In Nigeria is 11hrs, the total daily power requirement for charge= 3517.5/11= 319.77WH,
Assuming 20% Inefficiency, 120/100*319.77= 383.73WH
Using a 170W, 24V solar panel; Number of panel is 383.73/170=2.23 approximately 3 panels.

2.3. Inverter sizing

Total power of appliances = 1675W

For safety, the inverter should be considered 25-35% bigger in size (www.leonics.com)
Hence inverter size should be 2144W on the average.

2.4. Battery Sizing

The battery type recommended for use in solar PV system is a deep cycle battery. Deep cycle battery is specifically designed for to be discharged to low energy level and rapid recharged or cycle charged and discharged day after day for years. The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days (www.leonics.com). To find out the size of battery, calculation was done as follows:

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt-hours per day used by appliances}}{(0.85 \times 0.6 \times \text{nominal battery voltage})} \times \text{Days of autonomy}$$

Where 0.85 is the battery loss
0.6= depth of discharge. Note that, it is advisable to maintain a reasonable depth of discharge (DOD) to prolong battery's life.

From Table 1, total Watt –hour/day= 3517.5WH
Assuming nominal battery voltage= 24V
Days of autonomy (i.e number of days system needs to operate without power from PV panel)=2
Battery capacity= 3517.5/(0.85*0.6*24)*2
= 574.75AH

So the battery capacity should be rated 600AH, 24V for 2 days autonomy.
The specified components were further purchased from the market. Figure 1 shows the block diagram of the components arrangement.

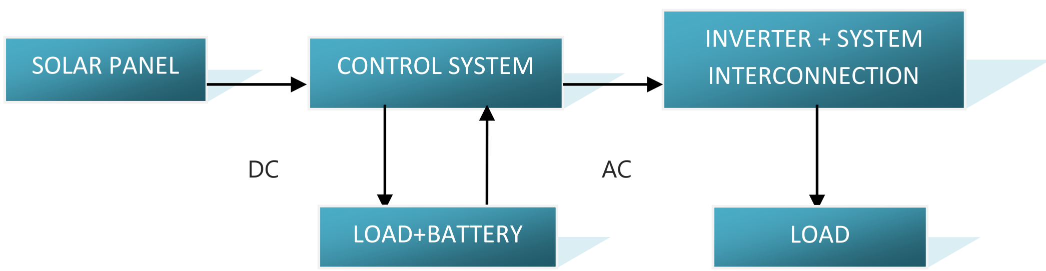

Figure 1
Block Diagram of System Components

2.5. Economic Evaluation

Table 2
Component Cost

Components	Number of Components	Price of Components (₦)	Cost Price(₦)
170W Panel	3	55,000	165,000
Inverter	1	140,000	140,000
Deep cycle Battery	2	50,000	100,00
Total			**405,000**

It is important to determine the cost effectiveness of this alternative energy source in comparison with operating on fossil fuel generators and a stable electricity supply. Table 2 shows the component cost price of the system assembly as at May 2012. Assuming Cost of labour is ₦40,500, the total cost for fabricating this system would be ₦445,500. The maximum lifespan of the panel is approximately 35 years, as stated by the manufacturer. Also, the maintenance needed is generally small, but it is necessary to keep the panels clean. If a 2.2kVA gasoline generator was used to power the appliances in a rural health centre, the fuel consumption is 0.38litre/hr. Since the cost of fuel per liter is ₦97 (May 2012).Thus, the total cost in a day is ₦884.64 and ₦322, 893/yr assuming continues operation.

Total cost in first year = purchase cost + cost of fuel + maintenance cost
Assuming purchase cost= ₦150, 000
Maintenance cost= ₦ 15,000
Thus, Total cost= 150,000 + 322,893 + 15,000 = ₦ 487, 893

If constant electricity is being supplied to the health centre and since cost of electricity supply per unit is approximately ₦15.00/KWh (PHCN May 2012). Therefore, the running cost of this 1675W load for 24hrs is 1675X24x15/1000=₦603/day and ₦220,095/Yr.

3. RESULTS AND DISCUSION

From the economic analysis, the cost of fabricating this energy system is ₦445, 500. By comparing this value with the cost of running on fossil fuel in first year i.e ₦ 487, 893, it is obvious that there will be an increase of approximately 7% of total expenditure on operating with fossil fuel in first year. Thus, will be an increase in cost savings in coming years if it is being powered by solar energy. Also, by comparing with the conventional electricity supply, since total cost of power supply in a year is ₦ 220, 095, this will equal the fabrication cost of solar powered health centre in approximately 2.5 yrs, which is approximately the breakeven point.

4. CONCLUSION AND RECOMMENDATION

The analysis has shown that the solar powered health center driven by solar PV is a stand-alone energy system and is economically viable. In a long run, solar power proves a cheaper energy source in operation. This reliable energy system will help to improve the state of health in our rural communities by being able to preserve vaccines/medicines for health care services and further encourage qualified medical practitioners to accept work offers in rural areas. Having demonstrated the effectiveness of a solar powered health centre; it is recommended that, Nigerian Primary Health Centres should implement this design since it is obviously cost effective in a long run and harmless to the environment.

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Conflict of Interest

The authors declare no conflicts of interests any matter related to this paper.

Data and materials availability

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Peer-review

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